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THE HAWAIIAN PLANTERS' MONTHLY

PUBLISHED FOR THE

HAWAIIAN SUGAR PLANTERS' ASSOCIATION

[Entered at the Post Office at Honolulu, T. H., as Second-class matter.]

VOL. XXVII.] HONOLULU, JULY 15, 1908. No. 7

SUGAR PRICES FOR MONTH ENDING JULY 10, 1908.

1908.		Cetrifugals.	Beets.	Parity.
June	10	4.40¢	11s 4½d	4.40¢
"	11	4.40¢	11s 4½d	4.40¢
"	12	4.40¢	11s 4½d	4.40¢
"	13	4.39¢	11s 4½d	4.40¢
"	15	4.39¢	11s 4½d	4.40¢
"	16	4.39¢	11s 1½d	4.35¢
"	17	4.36¢	11s 2¼d	4.36¢
"	18	4.3125¢	11s 0¾d	4.33¢
"	19	4.3125¢	10s 10½d	4.29¢
"	20	4.3125¢	10s 9¾d	4.28¢
"	22	4.3125¢	11s	4.32¢
"	23	4.3125¢	11s	4.32¢
"	24	4.25¢	11s	4.32¢
"	25	4.245¢	10s 11¼d	4.31¢
"	26	4.25¢	10s 10½d	4.29¢
"	27	4.25¢	10s 9d	4.26¢
"	29	4.25¢	10s 9¾d	4.28¢
"	30	4.25¢	11s 0¾d	4.33¢
July	1	4.36¢	11s 1½d	4.35¢
"	2	4.39¢	11s 6d	4.43¢
"	3	4.39¢	11s 6d	4.43¢
"	4	4.39¢	11s 6d	4.43¢
"	6	4.39¢	11s 4½d	4.40¢
"	7	4.39¢	11s 6d	4.43¢
"	8	4.39¢	11s 6d	4.43¢
"	9	4.39¢	11s 6d	4.43¢
"	10	4.39¢	11s 5¼d	4.42¢

Messrs. Willett & Gray in their Weekly Statistical, dated June 25 and July 2, report as follows:

June 25, 1908—

As forecast in our market report last week, the week under review developed a weakening tendency resulting in a comparatively large business at 1/16c. per lb. decline to 4¼c. per lb. for 96° test basis. At this price buyers took all offerings and are still in the market for more sugar, showing that for the time at least the decline is checked, and the market is likely to hold steady under the influence of an increased demand for refined which is likely to come in the near future, but only after a possible reduction in refined quotations, temporarily.

The difference in parity between old crop cane and new crop beet is now 13c. per 100 pounds, against 17c. per 100 pounds last week. Arrivals were unusually large again, sugar coming in from all quarters of the sugar world indicating a visible supply on Sept. 1st larger than anticipated.

This change in forecast is necessary from the fact that the consumers in both the United States and United Kingdom are drawing largely on the so-called invisible stocks and a continuation of this policy will not show in statistics for the year the usual normal increase of consumption.

Receipts for the week were 47,634 tons, meltings 43,000 tons. Total stocks in the United States and Cuba together 438,362 tons, against 417,728 tons last week and 677,878 last year.

Regarding crops, our domestic beet crop sowings are increased 4.46 per cent. over last year, indicating an increase of 14,800 tons in the beet sugar crop, as shown in our special reports of this week. The prospects of the crop have improved recently and now look favorable.

The growing crops of Louisiana, Cuba, Porto Rico, Brazil and Demerara are all reported on the improving side, also the European beet crops continues favorable, as carefully watched and reported by Mr. F. O. Licht.

The two steamer cargoes (10,000 tons) beet sugar reported last week as loading at Hamburg, unsold, have been ordered to the River Tyne, England, for orders.

Nothing new is said about the influence of the Russian crop exports, such influence being already well discounted.

The market closes steady and firm at 4.25c. per pound 96° test Centrifugals, and 11s. 0¾d. for old crop beets ,the parity of 4.33c. for Centrifugals, and 10s. 0¼d. for new crop (October-December) beet, the parity of 4.12c. for Centrifugals.

July 2, 1908—

The reaction which took place, as noticed last week, proved to be the needed stimulus which the market required to put itself on the former level of prosperity.

Following the reaction, all markets turned strong and give promise of continued strength for some time to come. Europe is helped out of its inactivity by a renewed American demand, which took one of the steamer cargoes of beet afloat (noted as unsold last week) at 11s. 4½d. c. i. i., the parity of 4.28c. landed for Centrifugals, the buyers being the Federal refinery, followed by purchases of at least 25,000 tons beet-root sugar by other refiners for shipment, at equal to 4.31c. duty paid for 96° test Centrifugals.

Intermediate purchases during the week of Porto Rico Centrifugals (96° test) at 4.31c. and Cubas at 2 15/16c. c. & f., 95° test, equal to 4.33c. landed for 96° test, put the market again on a firm basis at .08c. advance for the week, with buyers at 1/32c. further advance and holders asking still higher prices.

Crop news is favorable from all countries by our reports, although other reports of European beet crops modify the favorable condition a little by fears of drought.

European markets declined to 10s. 9¾d. for beet, but quickly reacted, recovering more than was lost and closing at 11s. 5¼d. for July, being the parity of 4.42c. for Centrifugals, with new crop at 10s. 3¾d. for October-December delivery, the parity of Centrifugals at 4.18c.

Cane sugars advanced 4½d. on the London market.

No recent business is reported in Javas, which may be more scarce for early arrivals than anticipated. It is said that three cargoes are being shipped to Egypt and that a cargo now loading at Java is on fire.

Figures, just obtainable, showing the distribution of the domestic beet sugar crop, together with the statistics of the American seaports, enable us to publish this week the details of consumption of sugar in the United States for the first six months of this year, which has proved to be unexpectedly large, being 1,586,889 tons, an increase of 112,595 tons or 7.63 per cent. over the consumption for the same time last year. With the greater part of the domestic sugar crops disposed of and the fruit crop reports being unusually favorable, the indications point to heavy demand for the product of the seaboard refineries during the remainder of the year, even if the actual consumption meanwhile should possibly show a slight falling off.

At the close the market is firm, with principal buyers showing resistance to further advance at the moment, but with sales to Warner of Porto Rico Centrifugals afloat at 4.39c.

NOTES.

THE FUTURE OF EUROPEAN IMMIGRATION TO HAWAII. Congressional legislation permitting the bringing in, by the Territorial Board of Immigration, of European immigrants having failed, the question which naturally suggests itself is what can legally be done by the Government, or the sugar interests, toward obtaining desirable white immigrants.

In discussing the question of immigration of Europeans, necessarily, under the present condition of agricultural development of these islands, one refers to such people as are fitted for, and will work on the sugar plantations. There is no escaping the fact that there is very little opportunity for employment of any number of unskilled laborers other than on the plantations.

There are three lines of activity which suggest themselves.

Acting upon the suggestion of the Federal Bureau of Immigration, the local Board of Immigration is perfecting its plans to endeavor to obtain Europeans from Ellis Island. An office will be established there in charge of a man alive to the situation, and who having the opportunity of personal investigation, will be thoroughly familiar with the local problems involved.

There are seemingly great difficulties to surmount in this undertaking. The matter of persuading a desirable class of people to come, the question of transportation, are both problems which will require considerable skill to work out. It will not be feasible to send an occasional family of immigrants on the long journey from New York to Honolulu, and unless considerable numbers can be obtained the scheme will not be successful. But the effort is being made in earnest and no points are being overlooked.

Should this fail, there are two courses left. The first is to begin an endeavor to influence Congressional action so that the Board of Immigration will be permitted to bring people here with funds supplied by subscription from private sources. The bill before the last Congress having this end in view met with overwhelming defeat, but the opposition on the part of some of the Congressmen was principally due to a lack of information, and it may be that more favorable consideration will be given to the measure at the December session.

Should this course prove futile, and the general immigration law remain as it now stands, the only other relief is through the Hawaiian legislature. States and Territories are permitted by the Federal law to solicit immigration and pay the transportation of immigrants by the use of public funds. In our own instance no funds for this purpose are available, nor at the present rate of taxation could any large amount be appropriated for this purpose. It would mean an increase of taxation, or a special tax upon the sugar interests. An increase in the rate of general taxation would be viewed with great disfavor, and special taxation would, of course, be undesirable from many standpoints, but under all the circumstances might be the only course left to follow.

It is time for those who will bear the burdens to put on their thinking caps and decide whether European immigration is to be resumed, and along what lines the efforts are to be made to that end.

MACHINE FOR CUTTING SUGAR CANE TRASH. A machine for cutting sugar cane trash on the fields in order that it may be plowed under as fertilizer has been recently invented by William J. Kent of New York. The specifications which he has filed in the Patent office give the following information in regard to his invention:

This invention aims to provide a practical apparatus, which in moving through a sugar cane field after the canes have been cut and removed, will pick up from the ground the tangled mass of leaves and cane tops called "trash," lift to a cutter, and cut them into small pieces which are dropped back on the ground so that they may be plowed under as a fertilizer. Some efforts have been made to devise machines for this purpose, but heretofore, so far as I am aware no machine has been produced which is capable of successfully picking up this material from the ground and feeding it to a cutter. The fertilizing value of the trash, if successfully reduced to a condition which will admit of plowing, and which before plowing will not obstruct the percolation of rain into the soil, is very great. It is nevertheless the general, and as I believe, the invariable practice to burn this refuse as soon as it has become sufficiently dry, a process which is attended with the disadvantage of losing the entire value of the nitrogenous constituents of the trash as a fertilizer, and of injuring the cane roots, so as to impair their capacity to send up new shoots the following season.

According to my invention I mount upon a suitable constructed vehicle a revolving rake at the front thereof, which turns backwardly so as to sweep the ground in rearward direction, whereby to pick up and disentangle the trash, and sweep or throw it onto a conveyer in rear of said rake by which the material is carried rearwardly and elevated sufficiently to bring it to the feeding and cutting mechanism; the feeding device consists of a pair of rolls between which the layer of trash enters and by which it is squeezed, compacted and crushed, and fed regularly to a revolving cutter, the blades of which, by acting against a fixed blade, shear or chop the material into fine pieces. As the cutter blades are disposed transversely to the path of movement of the material, it is important that the material shall be so presented as to enter between the rollers in endwise or longitudinal manner, in order that the leaves and stalks of canes may be cut or chopped off transversely, rather than longitudinally. It is to the attaining of this result that my invention is especially directed, it being found that in prior attempts the trash would, in the act of picking it up, be presented transversely to its movement, except to the extent that the tangled mass was not materially rearranged, and hence the cutting would be largely ineffective. To this end the revolving rake is especially constructed so as to have the novel function of straightening out and turning endwise the leaves and cane tops in the act of transferring them from the ground to the conveyer.

Conceding that Mr. Kent's machine is capable of doing all that he claims, it is a question whether it is desirable to plow the trash into the soil. It is true that a great deal of fertilizing material is lost in burning the trash; but under the conditions that exist here there are great advantages in burning off the fields after harvesting. The burning of the trash kills vast numbers of cane borers, and other insect pests, which live not alone in the trash that would be cut up by such a machine as Mr. Kent's, but also in the dead canes; this burning has proved to be one of the best methods of keeping the borer under partial control. So beneficial is the burning of the fields, that some of the plantations have gone a step further, and abolishing stripping, burn the fields before harvesting, with a saving of the cost of stripping, and enabling the plantation to do the harvesting at less expense, and furthermore almost largely ridding the fields of the borer.

In those districts where root, rind and leaf diseases are prevalent, the burning of the fields is a distinct advantage, and the fertilizing value of the trash would hardly be equal to the losses which would follow from plowing back into the soil the infected material.

STRIPPING TESTS AT HAKALAU PLANTATION. Mr. Eckart must feel particularly gratified with the results of stripping tests conducted at the Hakalau Plantation, which though not definitely settling the question of stripping in the Hilo District, would seem to demonstrate that even in the wet districts stripping is not, as has always been urged, an absolutely essential element in the cultivation of sugar cane.

CUBAN SUGAR PLANTATIONS. Consul-General James L. Rodgers, writing from Habana, makes the following report on the control and output of sugar plantations in Cuba:

The latest statement as to the ownership of Cuban sugar plantations, meaning those which are producing sugar and not cane alone, assigns 36 to Americans, 76 to Europeans, and 74 to Cubans, a net gain of 3 plantations over 1907, the gains showing 5 to Americans and 4 to Cubans, while the Europeans lost 6.

Whatever may be the ownership no one has as yet been able to put an accurate valuation on the plants, this being due principally to the varying quantities of land possessed by the companies producing sugar. In some of the old "centrals" and "ingenios" there is vested proprietorship over large tracts, and while only a small portion of the land may be planted, the whole of it may be included in the assets. Thus the estimate of values may well run from $50,000,000 to many hundred million dollars.

Assuming that the ownership is as stated, it can be seen that the foreign holdings in Cuban sugar plants are now over 60 per cent. of the whole and presumably with a much greater proportionate value, since the American mills especially are of the most modern and efficient construction, while many of the mills credited to Cubans are of obsolete type and barely able to produce sugar at even a high cost. The European mills generally occupy the middle ground as far as value is concerned.

As to production on the basis of the 1907 output which represented the maximum of endeavor, the American mills produced 30 per cent. of the total, the Cuban 35, and the European 35. As the number of American mills is given at only about one-half of the Cuban and European number, the size and efficiency can be easily perceived. Furthermore, the statistics of 1908 will undoubtedly show that the production from the American mills will be greater than either of the others.

ASIATIC SUGAR TRADE. American sugar merchants have made immense purchases of Java crude sugar, London merchants following a similar course. This has forced up the market for Java sugar from 6.10 to 6.60 yen per picul ($3.04 to $3.29 per 133⅓ pounds). The activity shown by the American merchants is due to the revival of trade in the United States and the failure of the sugar cane crops in Cuba, the latter showing a decrease of about 30 per cent. on the figures for a normal year, which amounted to 1,300,000 tons. Over 700,000 tons out of 1,400,000 tons of the total production in Java have been contracted for by American and British merchants, and the sugar market this year will be greatly affected. The stock of Java crude sugar in Japan is not more than 40,000 tons, which, added to the new sugar purchased for forward delivery by the Japan Sugar Refining Company, shows a total not much exceeding 52,000 tons. This is not regarded as sufficient to last for more than three months, so far as the operations of the Japan, Yokohama and Kobe sugar refinery companies are concerned.

Consul-General William H. Michael, of Calcutta, reports that notwithstanding a home production of 2,076,250 tons of cane sugar, India imported 9,730,713 hundredweight of sugar, valued at $27,276,092, in the fiscal year ended March 31, 1907. Of the imports, 5,926,879 hundredweight were cane sugar, and 3,803,834 hundredweight beet sugar, the latter being imports from Austria-Hungary, Germany, the United Kingdom, etc.

BRITISH LABOUR ON QUEENSLAND SUGAR FARMS. Last autumn a considerable number of labourers from Great Britain were sent by the Queensland Government under agreement to work in the sugar-growing industry, a minimum wage of 25s per week and all found being guaranteed to them. A number of labourers from various European countries were also sent out, and writing recently to a correspondent the manager of one of the leading sugar companies states: "The British labourers have so far proved their general superiority to the men from the Continent for the trying work of cane harvesting; but, of course, we have yet to ascertain if they will keep their good record during the wet season, which is now in progress. * * * The earnings of the majority of the immigrants during the past crushing season were probably twice as great as the 25s per week and found minimum that was promised in the agreements."—Glasgow Herald.

JAPANESE LABORERS IN CHILE. Certain of the Chilean newspapers, some of them of the greatest influence, have begun a campaign against the importation of Japanese laborers, who are being taken into the country to work in the nitrate industry. It is claimed by these journals in Chile, as in other countries, the Japanese laborer is a menace to the native workmen at the low prices at which he is willing to work.

FEWER CUBAN IMMIGRANTS. A decrease of 23,000 in the number of immigrants to Cuba last year as compared with the number arriving in 1905-06, is shown by a report issued by the immigration bureau of the Hacienda. During the last fiscal year there arrived in Cuba from foreign countries 29,572 immigrants, and in the fiscal year of 1905 and 1906 there arrived here 52,652 immigrants.

It was noticeable that the chief falling off was in the number from Spain. The decrease was 22,494, constituting almost the entire number. There is also a difference of 675 in the number arriving from North America.

This is explained by the strict enforcement of old laws in Spain in order to prevent the emigration of large numbers of laborers. Had it not been for this action on the part of the Spanish officials the number of immigrants to Cuba from Spain would have been greatly increased on account of the great amount of public work in progress on the island, which caused a demand for Spanish labor at good wages.

The number of immigrants and their nationality, is as follows: Germans, 80; North Americans, 1,709; South Americans, 143; Antilles, 953; Arabians, 182; Armenians, 1; Austro-Hungarians, 36; Belgians, 13; Chinese, 8; Dominicans, 3; Scandinavians, 100; Scotch, 10; Spanish, 22,178; French, 281; Greeks, 81; Hollanders, 25; East Indians, 26; English, 2,044; Italians, 215; Japanese, 4; Mexicans, 132; Persians, 2; Portuguese, 26; Porto Ricans, 71; Russians, 9; Syrians, 294; Swiss, 13; Turks, 264; and other nationalities, 20.

Of the total number of 29,572, 23,831 were men and 5,741 women. Of this number 23,685 were able to read and write and 20,373 had occupations.—Havana Post, May 26.

MR. PRINSEN GEERLIGS' LATEST WORK.* This book, which has just reached us, consists of 450 pages, and is the last that has come from the pen of Mr. Prinsen Geerligs.

The work is divided into three parts; the first, containing an account of the raw material, occupies 82 pages, and gives a detailed account of the composition of the cane and of the chemical and physical properties of the bodies therein found.

In the second part, which constitutes the bulk of the book, every station in the sugar factory is treated in detail, extraction is dealt with in 32 pages, attention being given to the Naudet process and to the Perichon method of megass extraction; the chapter on this subject concludes with some very pertinent remarks on the fuel value of megass. Nearly 100 pages are occupied with the purification of the juice, considerable attention being given to the question of choice of lime; the agents other than lime which have been proposed for this purpose are described, and the chapter concludes with a discussion of filters and filtering media. Evaporation of the juice and graining in the pan is described in 115 pages, the treatment being very full, and including such points as scale in evaporators, the brasmoscope, remelting of low sugars, conservation and deterioration of sugars.

Over 60 pages are occupied in a discussion of molasses, a subject which Mr. Geerligs discussed in a classic memoir so long ago as 1893.

The last part of the book deals with methods of control, and is especially valuable, as it contains the results of 96 Java factories for the year 1906.

Although concerned principally with Java, this book is a general treatise in every way, and results obtained in parts of the world other than Java are fully discussed.

Mr. Geerligs has just retired from a post that he has occupied for upwards of twenty years with credit and honor to himself and with invaluable benefit to the cane sugar industry. Although there has been nothing epoch making in Mr. Geerligs' work, the services he has rendered to sugar manufacture are not unworthy of being compared to those rendered by Pasteur to the brewing industry in France, or by Lawes and Gilbert to British agriculture, and the appearance of this book is a fitting termination to Mr. Geerligs' direct connection with the cane sugar industry.

An English version is to appear shortly, when a copy should be found in the possession of every one connected with the cane sugar industry. N. D.

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* Hand boek ten dienste van de Suikerriet Cultur en de Riet-Suiker Fabricaje op Java. Derde deel. De fabricatie van suiker int Suikerriet op Java: Door H. C. Prinsen Geerligs. pp. XXIV—449—XX. Amsterdam—J. H. de Bussy. 1907.

WHAT PROTECTIVE TARIFF MEANS TO HAWAII.

By E. E. Paxton.

The era of protection began in these Islands with the Reciprocity Treaty, which went into effect Sept. 9, 1876. Under the terms of the Treaty, certain articles from Hawaii, principally sugar, bananas and rice, were admitted into the United States free of duty, in return for which the Hawaiian Kingdom admitted free a large number of manufactured articles, building materials and supplies, the products of American farms and factories.

In 1887 a new treaty was made, extending the reciprocity relations for a further period of seven years, and granting to the United States the exclusive right to establish a coaling station at Pearl Harbor.

STATUS PRIOR TO THE TREATY.

But little progress had been made in the way of material development prior to the Treaty. The whale fishery, which for a time brought considerable revenue, had decayed, as well as the short-lived trade in sandalwood. Agriculture was begun long before the discovery of gold in California, and occasional shipments of potatoes and other provisions were made to the Coast; but the wide expanse of ocean between Hawaii and any possible market compelled her people, then, as now, to seek some world staple like sugar which might bear the long and expensive journey and be reasonably sure of a market when it reached destination.

When the Treaty was signed, the total output of sugar in the Islands was only 12,540 tons per annum, although the industry had been started a quarter of a century prior thereto. Business of all kinds was at a standstill. The planters had no money with which to expand their plantations, nor could they borrow it, so precarious was their only source of revenue. Hardly a plantation was operated at a profit, and several of them had passed through bankruptcy. Only in the most favored localities could they hope to survive. The high American duty on sugar then prevailing, ranging from three to four cents per pound, and the low cost of production in competing countries left no profit.

It must be remembered that the natural conditions in the Hawaiian Islands render the production of sugar very expensive as compared with European beet sugar, or the cane product of Cuba, Java, India, and, in fact, almost any other tropical country. In Cuba, for instance, the sugar cane springs almost spontaneously from the soil, maturing quickly during the moist, hot summer season, and grows on year after year from the same roots with comparatively little cultivation. In Hawaii, the volcanic soils have to be forced into activity with the aid of high-priced fertilizers and irrigation in most localities from artesian wells and mountain streams at a tremendous cost. Enormous investments in pumps, canals, reservoirs, mills, etc., have to be made and for real genuine daring enterprise the sugar business of these Islands can hardly be surpassed, especially in view of the fact that some of the largest undertakings have not as yet made any financial returns to their stockholders.

EFFECTS OF PROTECTION.

In 1891, the so-called McKinley Bill went into effect. This was fifteen years after the Treaty was made. The output of sugar had increased from 12,540 tons per annum to 146,174 tons, or more than eleven-fold. The total commerce of the Islands had grown from $4,052,813 to $17,698,271, and not less than fifty millions of American capital had been invested. Railroads had been constructed on Oahu, Maui and Hawaii; inter-island steam transportation had been developed, and Honolulu had grown from a semi-native fishing village into the modern civilization of an American city.

The McKinley Bill admitted all sugar under 16 Dutch Standard into the United States free of duty from every country, and granted a bounty of from 1¾c. to 2c. per pound on domestic production. The effect of this law was to place Hawaiian sugar on the basis of the world's market, and well-nigh paralyzed the industry in these Islands. Several of the weaker plantations were abandoned, and the entire country was threatened with ruin. Had this condition lasted for any considerable period, it would have almost annihilated the sugar business in Hawaii. Only by inaugurating the most rigid economy and seeking the most advanced methods of manufacture could the best plantations hope to exist when the protecting arm of the tariff was withdrawn.

In October, 1894, the Wilson Bill restored the duty on sugar, fixing the rate at 40 per cent, ad valorem on raws and an additional one-eighth of a cent per pound above 16 D. S. and refined. This was followed by the Dingley Tariff Law of 1897, now in force, which established the duty on basis of polarization, commencing with .95c. for sugar polarizing 75° and under, and .035c. for each additional degree. This makes the rate on 96° sugar (the usual standard) 1.685c. per pound, as against 3.44c. when protection was first extended under the Reciprocity Treaty.

In 1898 came annexation to the United States, and with it an undue impetus to expansion of the sugar industry, greatly overtaxing the financial resources of the Territory. The result is that the present output has reached a half-million short tons, undoubtedly very near the maximum, as about all of the available cane land has been utilized.

BENEFITS TO MAINLAND INDUSTRIES.

And who have been the gainers under this system of protection and progress in these Islands?

The reply is sometimes made that the benefit of protection has reached only a handful of so-called "sugar barons," and that the people of the United States have paid for it. No more unjust or one-sided statement could be made, and can only disclose ignorance and disregard of true conditions.

Since the Reciprocity Treaty was adopted, the people of the United States have received the enormous sum of $215,000,000 for exports to Hawaii, products grown on American farms and manufactured in American factories. The average Hawaiian planter (or planting company) must equip his plantation with a $500,000 mill, the materials for which come from America and are protected by heavy duties; in many cases, he must install pumps and pipe lines, made in America, costing, say, another half million, and likewise protected; he must expend many thousands of dollars in railroads, engines, cars, live stock, etc., and which, for the most part, enjoy similar benefits of protection as those accorded to sugar. After his plantation is once started, he must buy his fuel oil from California fields, the materials for the renewals of his machinery and equipment from Eastern factories; his hay, grain, flour, and a thousand and one articles which constitute the major portion of the cost of producing sugar,—all from the United States.

Another important consideration is the value of Hawaii's carrying trade to the American merchant marine. In accordance with the existing navigation laws, all merchandise shipped to and from the Islands must be carried in American vessels representing a total investment of not less than fifteen millions of dollars. Much is being said and written in regard to the decline of the American carrying trade with foreign countries. The total foreign commerce of the United States carried in American bottoms during 1907 was valued at $318,331,026; the total value of imports and exports from and to the Territory of Hawaii carried in American vessels for the same period was $44,572,958. In other words, the value of little Hawaii's commerce was 14 per cent. of the entire foreign commerce carried under the American flag for the year 1907.

The total value of the commerce of the United States with its non-contiguous territory (Alaska, Porto Rico, Tutuila and Hawaii), exclusive of gold and silver shipments, was $63,340,079 for 1907, of which Hawaii's share was $43,178,957, or nearly 70 per cent. of the total.

CUSTOMS REVENUE FROM HAWAII.

Nearly 80 per cent. of Hawaii's imports are from the United States. Notwithstanding the large proportion of free importations, she has paid since annexation the tidy sum of $10,000,000 in round numbers into the National Treasury to help run the general Government. The amount of customs revenue paid in per capita by the people on the mainland of the United States in 1907 was $3.89; the average amount paid by every man, woman and child in Hawaii on an estimated population of 200,000, for the same period, was $7.30. While Hawaii's contribution may be small compared with the National expenditure, she is certainly doing her full share in bearing the burden when she pays out of her own pocket nearly double her per capita proportion.

PROTECTION AND FUTURE DEVELOPMENT.

As the production of sugar has about reacher its maximum in these Islands, further development of resources must be in the way of diversified agriculture, that is to say, such staple products as will bear long-distance transportation and be marketed at a profit. An illustration of this is the growth of the pineapple industry during the past few years. Prior to annexation, Hawaiian pineapples were subject to the regular duty imposed by the Dingley tariff of 25 per cent. ad valorem if canned in their own juices, and if preserved with sugar, 35 per cent. ad valorem and one cent per pound, the fresh fruit being subject to a nominal duty of $7.00 per thousand pines or 7 cents per cubic foot in bulk. A few small plantations had been started, but the industry languished with the attempt to sell fresh fruit in the limited Coast markets, without adequate transportation facilities, and was on the verge of abandonment. With the stimulus afforded by protection, this industry has developed by leaps and bounds, the total estimated output for the present year being 388,000 cases, valued at $1,200,000. No other tropical product is so well adapted for the moderate investment of capital and the utilization of small areas not otherwise remunerative.

Here, again, the mainland manufacturer and freight-carrier comes in for his full share, in a larger proportion even than in the case of sugar. For every ton of canned pineapple, valued at, say, $79, there must be expended not less than $25 for supplies purchased in the American market, and transported in American vessels; and at the same time the great consuming population of the United States is furnished a product of a quality universally admitted to be far superior to anything of its kind produced elsewhere in the world.

Recent experiments by the U. S. Government have demonstrated, almost to a certainty, that tobacco of a very superior quality can be produced in certain localities. If the experiments now being made on a commercial scale by private enterprise are successful, this product will be a factor in the future possibilities of the Islands, provided it is not brought into direct competition with the fields of Cuba.

As the Territory of Hawaii is now an integral part of the American commonwealth, her people are in exactly the same position as the beet-growers of the West, the cane and tobacco planters of the South, and the fruit producers all over the country. None of these interests can stand direct competition with the tremendous possibilities of Cuba, or the low cost of European beet sugar. Tariff concessions to those countries mean stagnation and death to the sugar and tobacco interests of America, the combined output of which is valued at not less than $175,000,000 per annum, for raw products alone.

EXAMINATIONS FOR SUGAR CHEMISTS IN JAVA.

During the months of March and April of this year, examinations were held in Java for sugar chemists, at which 88 candidates presented themselves, of whom 27 were successful in obtaining the diploma which permits them to officiate in this capacity in the mills of the syndicate. The examinations were divided into three sections, written, oral and analytical chemistry. That a preparation of no ordinary standard is required of these applicants before the important position of control work is entrusted to them is evident from the questions included in the written examination, which follow:

THEORETICAL CHEMISTRY.

1.—What is Fehling's test? Describe its preparation and action on glucose.
2.—What do you understand by inversion and through what means do you bring it about?
3.—Define acids, bases, salts. Give an example of each.
4.—What do you understand by normal or tenth normal hydrochloric acid and soda solution, and how are they prepared?
5—What is magnesium mixture and for what is it used?
6—What is oxidation and reduction? Give two examples.

MANUFACTURE.

Describe the manufacture from cane to sugar according to one of the processes—Muscovado, sack sugar, and molasses; or Muscovado and molasses (according to choice).

In addition, treat more extensively the following points:

(*a*) Defecation of juice (regulation of liming, influence of lime on the various ingredients of the raw juice, filtering of the scums, composition of press-cake).

(*b*) Evaporation.

(*c*) Boiling.

Answer, according to choice, one of the following questions:

1.—What is the object of sulphuring and how it is performed?

2.—If a boiling of 70° purity is made from syrup of 82° purity and molasses of 60° purity, what percentage of the solids in the boiling originates with the syrup and what with the molasses?

3.—What is the approximate composition of cane, raw juice, muscovado, first sugar, sack sugar, and molasses in Java? (Brix, Polarization, Quotient, Glucose, Ash.)

FACTORY CONTROL.

1.—What is the significance of the formula which gives the amount of crystallizable sugar in the product? Does it really give the actual amount? How is it deduced?

2.—The formula $X = 100 \times \dfrac{\text{Purity massecuite—Purity resulting molasses}}{\text{Purity sugar—Purity resulting molasses}}$

reports the amount of sugar (Brix = 100) of the given purity which can be obtained from 100 parts of dry massecuite. How is this formula proven?

3.—Required from figures taken from actual factory work to fill in table showing losses, etc., calculated and actual.

4.—How does one find in the daily report the temporary number for the quantity of sugar in 100 cane, and how are these numbers corrected in the collected reports (periods of ten or fourteen days), to the definite figure? How are the "calculated cane-weights" determined?

5.—There are obtained in a mill from 100 cane, 90 parts juice of 15.3% sucrose and 90° purity. The fibre in the cane is 10%, and there remains in the bagasse 0.85% sucrose on 100 cane, the moisture being 45%. If the purity of the last mill juice is 85%, how many kilograms of bagasse are available for 100 liters of water in the juice present?

6.—Give examples of methods of estimating available sugar and interpretations thereof.

7.—Define imbibitions.

STEAM MECHANICS.

1.—(*a*) A factory works a maximum of 10,000 picols cane (1 picol=62 kilograms) in 24 hours. From each picol are obtained 55 liters mixed juice. What must be the diameter of the piston of a single acting juice pump with a 400 m. m. stroke, which makes 50 revolutions per minute?

(*b*) What must be the length of the stroke of a Worthington pump which must have a capacity of 550,000 liters of juice, the cylinder being 150 m. m. in diameter and the pump making 40 double strokes per minute?

2.—An engine makes 60 revolutions per minute. If the gearing is 1 to 22, how many revolutions does the top roll make per minute? The diameter of the latter is 30 inches. What is the speed of the circumference of the rollers per minute in meters?

3.—Problem with diagram to determine weight on safety valve for a prescribed pressure.

4.—Why is it more economical to evaporate the clarified juice in a quadruple than in a single effect? What do you understand by the coefficient of heat transmission, and on what is it dependent?

5.—How many kilograms of water at 60° C. are vaporized to steam at 90° with 5 kilograms of steam at 120°? The condensed water flows off at a temperature of 100°.

6.—How many kilograms per square meter correspond to a pressure of 75 pounds? How high is water drawn up in a pipe above which is a vacuum of 25 inches?

7.—Describe what pan accessories you know, and what purpose they serve.

8.—Describe the arrangement and working of a condenser.

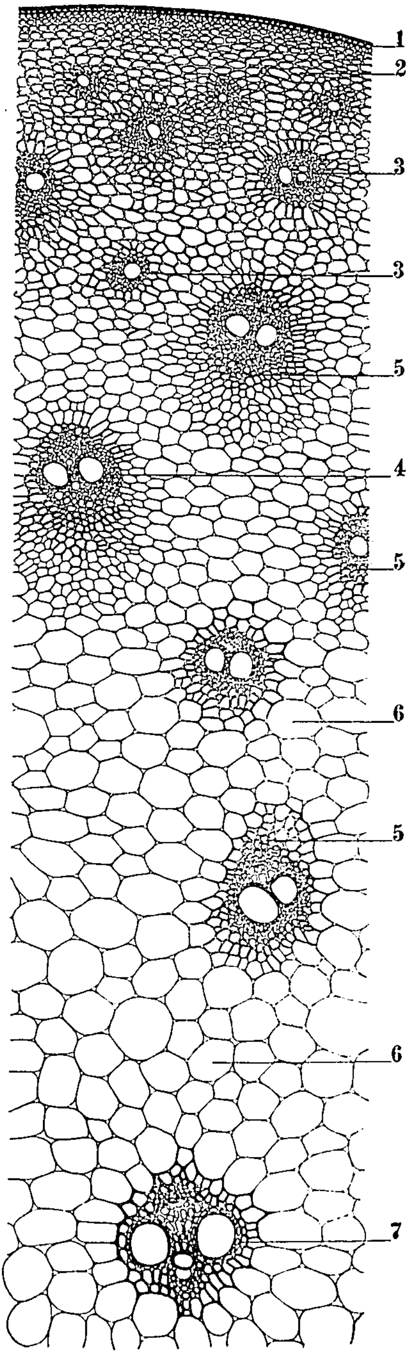
The "Indische Mercuur" in reporting the results of the examination says: "Among the candidates this year were one Japanese and several Chinese. Most of the applicants were students of two sugar schools. * * * Most probably there will be held in 1909 an examination for diplomas as syndicate mill superintendents, whereby the chaff will be well separated from the grain."

(Translated from the "Archief voor de Java Suikerindustrie" by S. S. Peck.)

RED ROT OF THE SUGAR-CANE STEM.

BY L. LEWTON-BRAIN.

(*Continued from last Number.*)



THE FUNGUS IN THE CANE.

It will not be necessary for me here to enter into any description of the anatomy of the cane stem. An elementary knowledge of the structure and functions of the stem and its tissues is of course essential to a correct understanding of red rot, but I have already dealt sufficiently with this question in an earlier bulletin,[17] and will refer those who are not familiar with the details to the descriptions and figures there. (Pp. 6-15.)

MICROSCOPIC EXAMINATION.

I have already mentioned that Wakker and Went in their description of the symp-

Fig. 11. Section through the outer part of a cane stem, as seen under the low power of a microscope. 1. The epidermis; notice the thick cuticularized walls, especially the outer ones; these walls are very tough, and are impervious to water, thus the epidermis protects the more delicate tissues inside. 2. Thick-walled ground tissue of the 'rind'; these cells are mainly mechanical, and help to strengthen the stem. They pass gradually into the thin-walled cells of the ground tissue, seen at 6. 3. 3. Small vascular bundles; these bundles are mainly mechanical, and are composed almost entirely of thick-walled elements. They are found mainly in the outer part of the stem; each contains only one wood vessel. 4. Intermediate bundle, with two wood vessels, and a few thin-walled phloem elements. 5. 5. 5. Thick-walled fibres; these are the mechanical elements of the bundles; they are proportionately much more numerous in the bundles toward the outside than in those nearer the center. 6. 6. Thin-walled cells of the ground tissue; they become larger as we approach the center of the stalk. In these cells the plant stores its reserve of sugar and other food materials. 7. One of the large vascular bundles found towards the center of the stalk; these are the chief conducting bundles; each contains two large wood vessels and one smaller, and a well marked phloem.

[17] Lewton-Brain. 'Rind Disease of the Sugar-Cane.' *ibid.*

toms of red rot state that occasionally, in advanced cases of the disease, a mould may be found growing in the cavities of hollow stalks. The following description of a microscopical examination of a diseased stem is taken from the account given by the same authors:[18]

> 'If one examines the diseased tissue under the microscope, it will be seen to contain the mycelium of a fungus, which is especially found in the parenchyma [the thin-walled, sugar-containing tissue shown at 6, in Fig. 11]. This mycelium appears to be characterized by the possession of a number of small oil drops [compare Fig. 12], soluble in alcohol and ether.
>
> 'The cane tissue appears to be dead, in consequence of which, in the red spots the cell-walls are impregnated with a red-brown coloring matter, which is lacking in the white spots. The contents of some of the dead cells have changed to a red-brown, granular mass. A formation of gum may appear in the vascular bundles, as well as in some parts of the parenchyma.
>
> 'The white spots are seen to be groups of cells, the contents of which have become replaced by air. If a white spot which has just appeared be examined, the fungus is always found; in older spots it is seen at the edges, but not always in the center. The fact seems to be that the hyphae slowly disappear, becoming dissolved in some manner, while the oil drops may still remain; one often finds these drops in rows, indicating the course of the former hyphae. In the red spots few hyphae are to be found. The fungus appears to secrete a poisonous substance which kills the surrounding tissue; as a result of this the cell-walls assume the red-brown color; as the fungus penetrates the dead tissue the red color disappears again; finally the fungus itself dies away behind, and all that is left are the cell-walls with air in their cavities.
>
> 'The fungus is also found in the vascular strands which pass into the buds, when the strands themselves show a red-brown color. In this case it is found that the hyphae are present mainly in the cells and the fibres of the vascular bundles, seldom in the vessels proper. The walls of the surrounding cells also show a red-brown color.'

This description agrees very well with what I have found in the few cases of red rot I have examined. One essential point to be noted is that it is mainly the thin-walled tissue that is at-

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[18] Wakker & Went. *ibid.* p. 38.

tacked; that is, the cells in which the sugar is stored, and not the vascular system; this agrees again with the facts noted in artificial cultures, that it is on media rich in sugar that the fungus grows

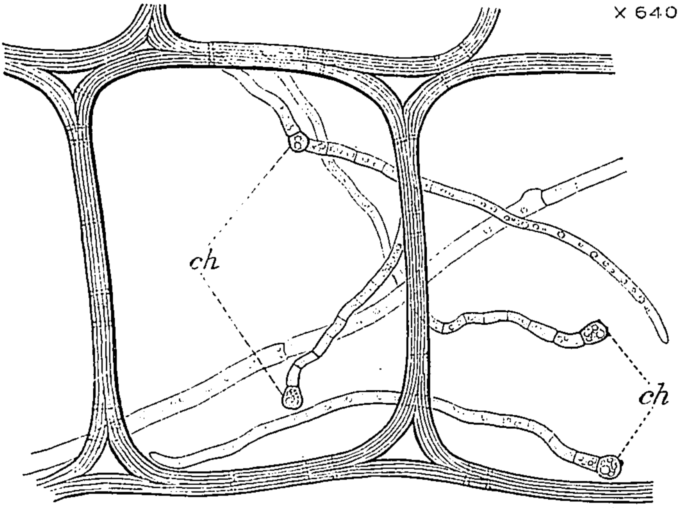

Fig. 12. Some of the cells from the interior of the cane shown in Fig. 2. A mycelium was first found which agreed to all appearances with that of *Colletotrichum*, finally in two or three preparations, the characteristic chlamydospores (*ch.*) were found connected with this mycelium, which left no doubt as to the identity of the fungus and the cause of the disease. The hyphae and chlamydospores should be compared with those shown in Figs. 5, 8, and 9, from pure cultures. The history of the cane from which the cells were taken is given at length on pages 6-8.

best. The characters of the mycelium should again be noted; these are shown in Fig. 12, representing a few cells of the thin-walled tissue, attacked by the fungus.

Method of Attack.

The red rot fungus is essentially a wound parasite, there being no record of its ever being found able to penetrate the unbroken rind of the cane. More than this, a mere surface wound in mature joints is not a favorable avenue for infection. In order that the fungus may successfully enter the cane and carry on its destructive work, it is necessary that it be introduced, artificially or naturally, into a wound that goes through the rind into the softer, sweeter tissues of the stalk.

CANE BORER.

It will be seen that the only wounds answering the requirements of the fungus, which are likely to be found in Hawaiian cane, are those produced by the borer (*Sphenophorus obscurus*). In Java, according to Wakker and Went,[19] the fungus gains entrance to the canes through borer and other wounds. Leaf-hopper punctures, which appear to be quite sufficient for the entry of the rind fungus when the cane is susceptible, do not go deep enough for *Colletotrichum falcatum*.

Supporting this view, which is based upon a study of the life habits of the fungus, is the fact that all the few canes I have examined here which have been atacked by red rot have been infected from borer tunnels. Moreover a number of managers and other plantation officers to whom I have pointed out the typical appearances of red rot have immediately recognized them as being characteristic of 'borer cane.' In this relation it is worthy of note, as a point requiring further investigation, that it has been shown by Mr. Deerr, in connexion with the Annual Synopsis of Mill Data, that the three plantations which last year had juice of the lowest purity, were the three accounted by the Entomological Division as the most severely affected by borer. It must be remembered, however, that there has never yet been a severe epidemic of red rot in these Islands. Indeed, in such cases it would seem that, as pointed out both by Barber[20] and by Butler[21] in India, the opportunities offered by borer wounds are by no means sufficient to account for the whole of the infections. The comparatively sparse production of spores by the fungus would render unlikely any wide spread infection of canes through wounds.

In considering borer infection the resistant powers of the canes must not be lost sight of. Thus it would be quite possible for canes of resistant varieties to be affected quite badly by borer wounds, and to be inoculated with the spores of *Colletotrichum*, and yet not contract the disease, the fungus not being able to make headway against the resistance of the cane tissues. There are three factors necessary to a successful infection — the presence of a wound, the presence of spores (or mycelium) of *Colletotrichum* in the wound, and, thirdly, a susceptible condition of the cane.

INFECTED CUTTINGS.

When the disease has become well established, it appears to pass to the epidemic stage by the planting of diseased cuttings. This, at any rate, is the conclusion arrived at by Barber in

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[19] Wakker & Went. *ibid.*

[20] C. A. Barber. 'Sugar-Cane in the Godaveri and Ganjam Districts.' *ibid.*

[21] E. J. Butler. 'Fungus Diseases of Sugar-Cane in Bengal.' *ibid.*

Madras, and Butler in Bengal, and there seems to be no other way of explaining the epidemics described by these authors.

The manner in which the eye becomes infected has already been described. In such a case the stick developing from that eye will be diseased from the beginning; the cane may grow away from the fungus for a time, in which case the upper internodes will be clean, while those lower down will be diseased; as the cane ripens, however, the fungus may make more rapid progress, and the whole stalk become diseased. In cases of infection from the cuttings it is usually possible to trace the source of the disease by observing that the discoloration starts at the base of the stalk.

It may happen that the attack on young cane is so severe that this is killed out. Wakker and Went describe a case in which a 'bibit garden' (special area for raising seed cane) of the Teboe Mas variety was almost entirely killed at the age of about six months. They also state that occasionally newly germinated plants are attacked, especially in nurseries, and that these die early, but if lateral buds have been developed, these may produce healthy canes. As a general rule, however, the effects of the attack are noticeable, if at all, only when the cane is mature, so that the presence of the disease is only recognized at the grinding season.

Progress of the Disease.

In whichever way the attack begins, the after progress of the disease is in essentials the same. The growing mycelium of the fungus probably secretes some substance which is poisonous to the living cells of the cane tissue. The hyphae then enter these cells, destroy their contents, and repeat the process until a considerable area of the cane tissue is killed and the contents of the cells are destroyed, or at any rate completely changed. As already mentioned, the fungus does not seem able to affect the harder tissues of the outer part of the stalk, nor does it enter the vascular bundles.

It is thus easy to understand why the general nutrition and health of the cane do not usually suffer. The sources of the food supply—the roots and leaves—are unaffected; and it is in the leaves also that the manufacture of elaborated foods—sugar, etc.—is carried on. This also is not interfered with. Furthermore, as the vascular transporting system is not invaded, the circulation both of raw food material, including water, and of elaborated foods, can go on normally.

The damage, then, to the cane, by the attacks of *Colletotrichum falcatum* is entirely direct, and is confined to the destruction of the thin-walled parenchyma (6, Fig. 11). As it is in this tissue that the sugar-cane stores its reserve sugar, and as it is for the sake of this sugar that the cane is cultivated, the damage from the planters' point of view, may be as great as though the cane were killed. The sugar, as will be shown later, is destroyed.

The extent to which the disease will progress depends upon the resistance of the variety, and probably upon the general health of the particular cane attacked. If the resistance of the cane is very marked, the fungus may not be able to penetrate far beyond the tissues bordering on the wound. In other cases the fungus may be able to spread through the soft tissue of the internode into which it has gained access through a wound, but may not be able to penetrate the harder tissues of the nodes, and so the attack will be confined to one joint, or only to those joints penetrated by the borer tunnels. This would appear to be the case with Yellow Caledonia variety, as will be seen from the account of the inoculation experiments. If the cane is susceptible the fungus may go on from one internode to another until the whole stick is affected.

It can also be understood how in very severe cases of the disease the cane plant may be killed out. This will happen when the destruction of the sugar and other foods goes so far that the plant has not sufficient for its own needs in the production of new leaves and roots; when this occurs the destruction will advance very rapidly, as not only the storage but the manufacture of food will be inhibited. This, however, would not appear to be common; usually the plant has enough food for its own growth beyond what is taken and destroyed by the fungus.

The actual damage done to cane is shown in the following results given by Wakker and Went.[22] There have been so few cases of definite red rot in these Islands that I have not been able to obtain any strictly comparable analysis of diseased cane here. Two sets of figures are given from different districts of the plantation first attacked:

I.

The cane was divided into severely attacked stalks (14.6 per cent. of the whole), slightly attacked (47.3 per cent.), and healthy (38.1 per cent.):

	Brix	Saccharose	Quotient of Purity
Severely attacked	16.3	13.38	81.9
Slightly attacked	19.2	16.81	87.5
Healthy	20.0	17.75	88.7

II.

Here the percentage of badly attacked was 10.4, of slightly attacked, 41.8, and of healthy sticks, 47.8.

The analyses show:

	Brix	Saccharose	Quotient of Purity
Severely attacked	15.2	11.13	73.0
Slightly attacked	17.2	13.72	79.7
Healthy	18.0	15.05	83.6

The authors point out that, corresponding to the decrease in saccharose, there is an increase in glucose, so that the presence of *Colletotrichum falcatum* in cane is a cause of the inversion of cane sugar. This will be brought out more clearly, later, in dealing with the cultures of the fungus on liquid media.

Butler[23] also gives comparative analyses of twelve diseased and twelve healthy 'Yellow Bourbon' canes, both some months from maturity:

	Brix	Sucrose	Purity	Available sugar in juice
Canes showing disease in its early stage........	11.3	8.0	70.8	4.7
Healthy canes from same plot	13.9	11.2	80.5	8.5

Other analyses given by him are of samples of ripe 'Kajli' cane, similar outwardly, but with the reddening of the pith indicative of the presence of *Colletotrichum* in one sample:

	% cane sugar	% glucose	Density	% juice to cane	Temp.
Unreddened cane.	19.09	0.509	1086	55.58	18° C.
Reddened cane...	13.70	2.04	1070	55.58	18° C.

These tables again show that the action of *Colletotrichum* is primarily an inverting one.

Through the kindness of the manager of the plantation concerned, I have obtained the following figures with regard to the one recorded case of red rot in these Islands. Analyses were

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[22] Wakker & Went. *ibid.* p. 43.

[23] E. J. Butler. *ibid.* pp. 6, 7.

made of sound and 'borer' cane from the field already referred to on pages 6-8:

	Brix	Sucrose	Glucose	Purity
Sound cane	18.2	16.00	0.33	87.9
Borer cane	16.75	12.10	1.26	72.2

It will be seen that these results, both as regards decrease of sucrose and increase of glucose, are strictly in agreement with those obtained from cane attacked by red rot in both Java and India.

INOCULATION EXPERIMENTS.

The evidence, so far presented, that the cause of red rot is the fungus *Colletotrichum falcatum* is incomplete. It amounts to having found in the diseased tissues a mycelium which appears to be very like that of *Colletotrichum* (Figs. 9 and 12); moreover, connected with this mycelium are found, in the diseased tissues, chlamydospores which are the same as those produced in the pure cultures of *Colletotrichum* (Figs. 5 and 12); further, on occasions stromata and conidia of *Colletotrichum* have been found on diseased cane, connected with the same mycelium.

There can, therefore, be no doubt that the mycelium found in the tissues is that of *Colletotrichum falcatum*. That this fungus is the cause of the disease has not been demonstrated; nothing is commoner than to find, in diseased and dying tissues, fungi which have nothing to do with bringing about the disease, but which are merely following and completing the work of the true active agent.

To prove that red rot is due to the attack of the *Colletotrichum*, healthy cane must be taken, it must be inoculated with spores or mycelium of this particular fungus, and with nothing else, and as a result of this inoculation the characteristic symptoms of the disease must be brought about. It is also always advisable to pick out certain other canes growing under exactly the same conditions as those inoculated and treat them in exactly the same way as the former ones, except for the actual inoculation with the fungus. If these controls do not show any symptoms of the disease while the inoculated ones do, then the connection between the fungus and the disease may be regarded as proved.

The matter, however, is not quite so easy as it sounds. Many parasitic fungi require certain special conditions, either of the host plant or of weather, before they are able to effect a successful infection; for this reason an inoculation experiment may fail, not because the wrong fungus is being tried, but on account of certain necessary conditions being absent; in this case the inoculations must be repeated under varied conditions, which often leads to valuable information being obtained. On the other hand, the spores of the parasite may be so abundant, and the conditions so favorable that the controls become infected naturally; in this case inoculation experiments can give results of but little value.

Java Experiments.

The experiments carried out by Went were the earliest, and gave results so conclusive that the connexion between red rot and *Colletotrichum falcatum* may be regarded as absolutely proved. In his experiments a small hole was made with a fine needle into some full grown joints and after that some conidia or some filaments of the mycelium of the fungus were introduced into the wound; the hole was then covered with tin-foil. Carried out in this way the infection succeeded perfectly. Thus in one instance a white spot was seen around the hole after ten days, slowly going over to a red margin. No spot was to be seen close to the periphery of the stalk. The edge of the red spot was sharply defined from the surrounding tissue. Microscopic examination showed the characteristic mycelium with oil drops in the parenchyma.

In another case a similar white spot arose twenty days after the infection, but by this time the red coloration had already extended almost through the whole joint.

Hawaii Experiments.

The experiments I have made with this fungus were started in June, July and August, 1906. To determine whether the fungus could attack any other part of the plant besides the stem, I stabbed a number of young leaves with a sterilized needle and introduced into the wounds spores from a pure culture of *Colletotrichum.* Different parts of the leaves were inoculated, and other leaves were stabbed also with a sterilized needle to serve as controls. Not one of these leaves showed any signs of infection; the tissues just around the wound dried up, but the rest of the leaf in every case remained perfectly normal.

In a second experiment three young shoots were stabbed with a sterilized needle, and the wounds were inoculated with spores from a plate culture of *Colletotrichum.* These plants were growing in pots under cover, the shoots were so young as not to have formed any 'sticks,' so that the inoculation was really one of young leaves and leaf-sheaths. The experiment was repeated, but in neither case did inoculated shoots or controls show any signs of injury, but both merely a drying up of the cells around the actual wounds.

Again, a number of young leaves of plants growing under cover were inoculated by placing on them drops of water containing spores of *Colletotrichum*. The plants were covered with bell-jars for two days, to give the spores time to germinate and if possible enter the plant tissue before they were dried. Again there was no infection.

The experiments, although they do not prove, at any rate tend to show, that *Colletotrichum* is not a parasite on the leaves and leaf-sheaths. When it occurs on these organs it is probably merely as a saprophyte, following rather than causing the death of the tissues.

At the time the inoculation experiments were being carried on, Yellow Caledonia (White Tanna) variety was the only cane available at the Experiment Plot of this Division. The inoculations were therefore carried out with this, one of the three standard varieties of these Islands.

Five canes were inoculated by placing spores of *Colletotrichum* from a plate culture into a wound made through the rind of the cane with a sterile needle. Internodes of different ages were used in the different canes, some quite young and soft, others fully mature. Five canes were stabbed in exactly the same way as controls, no inoculating material being introduced into the wounds. Care was taken that each inoculated cane was exactly matched by one of the controls, as regards size, position in the stool and general appearance, and the wounds were made in the same relative position in the two canes. The wounds were afterwards covered to prevent the introduction of fresh foreign material.

Two months later two of the pairs were cut and split longitudinally. The condition found is shown by the photograph reproduced in Fig. 13. In the controls there was a slight discoloration along the actual line of the wound, perhaps slightly increased by the activity of a number of mites which had succeeded in entering the stab. In the inoculated canes there was a red discoloration starting at the wound and spreading the whole length of the joint; there appeared to be indications that the disease was spreading through the nodes to the internodes above and below. It will be noted that the appearance of the diseased area is by no means 'typical,' there being none of the central white spots with their sharply defined, red border.

The last of the experimental canes were cut in June, 1907, twelve months after the inoculation. It was thought that by doing this the fungus would be able to grow for a part of the time under conditions which would most favor it. On splitting the canes, however, exactly the same condition was found as ten months previously. The fungus had not been able to progress beyond the first internode. Naturally, there was no sign of the disease externally.

That the discoloration was really due to *Colletotrichum* was proved by finding the mycelium and chlamydospores of this fungus in the diseased tissues. The absence of any discolorations

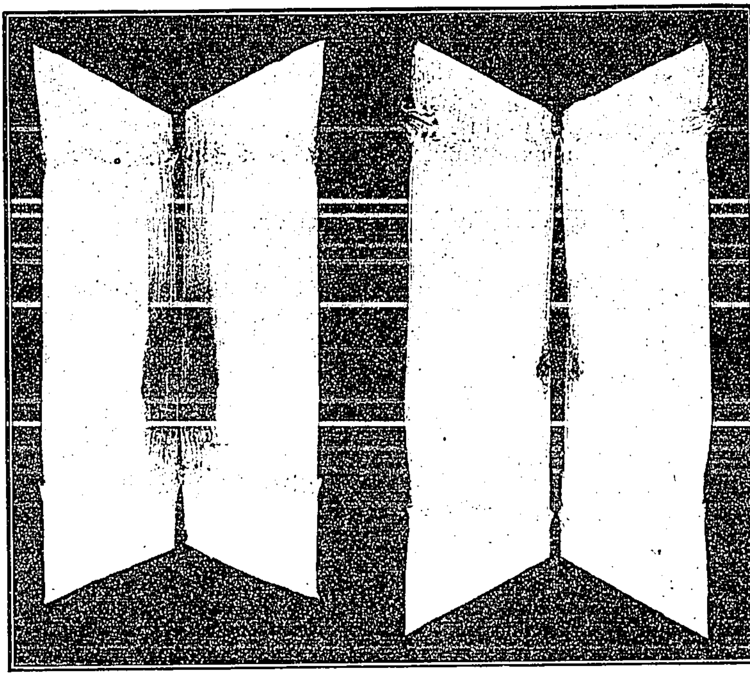

Fig. 13. Inoculation experiment with red rot. On June 29, 1906, the cane on the left was wounded with a sterilized needle, then spores of the fungus of Red Rot—*Colletotrichum falcatum*—were introduced into the wound. The cane on the right was wounded in the same way at the same time, but no spores were introduced into the wound. Both canes were cut and split open on August 20, when the photograph was taken. It will be seen that the inoculated cane shows discoloration through the length of the internode, while the control shows only a small discoloration at the wound. The variety used was Yellow Caledonia.

On June 12, 1907, other canes, inoculated at the same time as those shown, were examined. The disease had made no further progress, being confined to the inoculated internode. This shows that Yellow Caledonia is distinctly resistant to the Red Rot.

in the control shows the same thing. Stromata with setae were found in the edges of the wound.

The experiment is perhaps more instructive than if it had been more entirely successful. It was already known from Went's experiments that the cause of red rot is the *Colletotrichum falcatum* so a mere confirmation of this fact would not have added greatly to our knowledge of the disease. The experiment, however, shows in the first place that Yellow Caledonia variety, although not immune to the disease, is certainly quite resistant to it, a fact the knowledge of which may at any time prove of immense value. Again, it is proved that *Colletotrichum* does not always produce the typical symptoms described by Went and illustrated from a Hawaiian specimen in Fig. 1. This fact is also specially noted by Butler in the epidemic he describes (see p. 11), and is shown in the borer cane illustrated in Fig. 2. It may be noted that these latter specimens also belong to the Yellow Caledonia variety, and it looks as if the variety of cane attacked might be an important factor in determining the exact symptoms of the disease. More than this cannot be gathered from the small number of specimens examined.

INVERSION EXPERIMENTS.

The outstanding feature of the attack of *Colletotrichum falcatum* on the cane is the inversion of the sucrose. As has already been pointed out, apart from this very little damage is done to cane. It therefore seemed advisable to make some further investigations into this inverting action, using for the purpose sterilized fluids containing sucrose and pure cultures of the fungus, and so obtain more strictly accurate results than could be obtained from analyses of cane grown in the field where many other conditions might come into play.

I have to express my thanks to Mr. Noël Deerr, Mr. S. S. Peck, and Dr. R. S. Norris, of the Division of Agriculture and Chemistry, to whom I am indebted for the analyses of the solutions, and for much other assistance.

Experiments with the Living Fungus.

The first experiments were made by growing the fungus from pure plate cultures in flasks containing diluted expressed cane juice. The flasks were inoculated December 13, 1906, and with the controls were analyzed December 26; the results were as follows:

	Inoculated.	Control.
Sucrose	13.23 per cent	13.50 per cent.
Invert sugar	7.25 per cent.	6.60 per cent.

There thus appeared a loss of sucrose amounting to 0.27 per cent., while the invert sugar had increased by 0.65 per cent.,—equivalent to 0.62 per cent. sucrose. The controls had been treated exactly as the inoculated flasks during sterilization, etc., so that the only possible explanation of the anomaly was that the fungus must have destroyed one part of the invert sugar—the levulose, thus giving too high a reading for the sucrose. There was not enough of the solution available for more direct analysis.

The next experiment gave similar, but not quite such striking, results. I had thought it better to work with solutions of simpler and more definite composition than cane juices, and had inoculated two flasks of 10 per cent. cane sugar solution to which small quantities of nutrient salts had been added, two others serving as a control. The experiment was started December 26, before I had the results of the first test, consequently the quantities used were again insufficient for complete analysis. The results on January 9 were, the quantities being expressed as grams per 100 c. c.:

	Inoculated.	Control.
Sucrose	7.37	8.10
Invert sugar	2.51	1.50

Loss of sucrose .... 0.73 grams per 100 c. c.
Gain in invert sugar.... 1.01 grams per 100 c. c.

There was thus an apparent gain in total sugar (expressed as invert sugar) of 0.24 grams per 100 c. c., the sucrose lost per 100 c. c. being equivalent to 0.77 grams of invert sugar.

The next flasks were inoculated Jan. 4, 1907, larger quantities of the same solution being used. The results were, on Jan. 17:

	Specific Gravity	Sucrose	Glucose	Dextrose	Levulose	Reaction N/10 Acid
Control	1.0646	13.71	4.18	2.04	2.14	.23
Inoculated ...	1.0639	13.17	4.69	2.37	2.32	.375

Loss of sucrose .... 0.54 grams per 100 c. c.
Gain of glucose........ 0.51 grams per 100 c. c.

There was thus an apparent total loss of sugar equal to 0.06 grams of glucose per 100 c. c. solution. It is noticeable that while the dextrose in the solution has increased by 0.33 grams, the levulose has only increased by 0.18 grams, thus confirming the assumption that the actual loss of sugar falls upon the levulose.

The last experiment was started January 26, and the analyses made March 29, thus affording time for greater changes to take place. The results are given in the following table:

	Specific Gravity	Sucrose	Glucose	Dextrose	Levulose	Reaction N/10 Acid
Control	1.0640	14.11	2.10	1.19	0.91	0.22
Inoculated ..	1.0636	3.33	12.95	6.76	6.19	0.22

Loss of sucrose....... 10.78 grams per 100 c. c.
Gain of glucose .... 10.85 grams per 100 c. c.

Thus the apparent loss of sugar was equivalent to 0.49 grams of glucose, the whole of which appears to have fallen on the levulose. It may be mentioned that the solution as made up contained, per 100 c. c., sucrose, 18.16 grams, glucose, 0.20 grams; there was thus some inversion in the control solution. Probably this took place chiefly during sterilization through the inverting action of the salts, the chief one probably being the sodium hydrogen phosphate (Na_2HPO_4).

These experiments bring out, even more clearly than the cane analyses, the fact that the main activity of this fungus, as a destructive agent, is its inverting action. Moreover, in the experiments the results are certainly due to the fungus, and are not complicated by the presence of other organisms, or of agents such as enzymes which might be present in the living cane tissues. The action is very marked in the last experiment, where though more than 75 per cent. of the sucrose was inverted, not one-twentieth part of this was actually consumed by the fungus.

The question as to whether the fungus actually uses only the levulose portion of the glucose formed is very interesting. The quantities dealt with are very small, but all the experiments agree on this point, and there would seem to be no other explanation of the facts.

Experiments on Enzyme Production.

In a number of cases it has been shown that the inversion of cane sugar, both by plants and animals, is brought about not by any 'vital' activity of the protoplasm itself, but by the agency of a definite ferment or enzyme secreted by the protoplasm.[24] The inverting enzyme is known as 'invertase.' It has been separated

[24] For a general account of enzymes, including invertase, see J. Reynolds Green: 'Ferments.' Cambridge, 1899. Also Effront & Prescott: 'Enzymes and their Applications.' New York, 1902.

For more recent work on enzyme action, see W. M. Bayliss, 'The Nature of Enzyme Action.' *Science Progress in the Twentieth Century*, Vol. 1, October, 1906.

in a number of cases from the organisms producing it, and has been found to retain its power of inverting sucrose. Thus, for example, invertase has been separated from brewers' yeast and from germinating barley. It seems probable that there are a number of different invertases, differing in their activities and resistances to external conditions, but as it is almost impossible to obtain an enzyme in a state of complete purity, some of the observed differences may be due to variations in the impurities.

It seemed advisable, therefore, to attempt to determine whether the inverting action of *Colletotrichum* was likewise due to a production of invertase, and some experiments were carried out with this object in view. It was realized that very little beyond a proof of the presence of invertase could be attempted with the comparatively small amounts of material that would be available, and that anything in the way of an investigation into the properties of the enzyme, if it could be isolated, would be out of the question. There were two points that could be attacked; first, the question whether any invertase could be proved to be produced by the fungus; second, whether, if produced, it is secreted into the medium on which the fungus is growing, or is entirely confined to the mycelium. Butler was unable to secure any inversion by the juice in which *Colletotrichum* had been grown for a week. Apparently he did not attempt to extract the invertase from the mycelium. The experiments to determine whether any invertase is produced will be described first, although the others were carried on simultaneously.

Flask cultures in 20 per cent. sugar solution, with the necessary salts, were used. After a varying number of days the mycelium was strained off (the solution being again filtered and used for the other experiments) and washed. The small quantity of mycelium thus obtained, even from several flasks, was remarkable, and quite prohibited any attempts to separate out the enzyme. It was then thoroughly ground up, either with glass wool or with pure quartz sand; the ground up mass was allowed to stand for some hours, in contact with chloroform water to prevent any bacterial activity, then filtered. The extract was then added to pure sucrose solutions, together with a small quantity of chloroform, and polariscope readings taken daily. A control was always kept of the same sugar solutions with chloroform, to which no extract was added. These experiments were all carried on at room temperature (about 25° C.). The chief difficulty proved to be the getting a solution sufficiently clear to make accurate polariscope readings.

The first experiments gave the following results, the figures representing grams sucrose per 100 c. c. of solution. The readings taken were the average of five:

	July 11	12	13	15	18	23
No. 1	16.67	16.46	16.43	16.09	16.04*	
No. 2	16.20	16.12	16.09	15.91	15.70	15.29
No. 3 (control) ...	16.26	16.25	16.22	16.22	16.22	16.22

It is thus pretty certain that invertase was contained in the mycelium, and that some of it was extracted by the grinding. The figures are quite consistent, and show a distinct falling off in the solutions containing the extract.

In the next trial the mycelium was ground for two hours with pure quartz sand in a glass mortar; the mass was then allowed to stand over night with chloroform water, then filtered under pressure and finally with alumina cream. The solution was still cloudy, and accurate readings were impossible. However, they showed after three days that there was no falling off in the sucrose. It was hardly conceivable that a mycelium fourteen days old should on that account contain no invertase, while the enzyme had been extracted from one seven days old. The only explanation seemed to be that the invertase had been carried down by the alumina cream in the filtration, although the cream had been added to the extract and not precipitated in it.

The third experiment was with a mycelium three weeks old, the idea being to test the possibility of the invertase varying with the age of the mycelium. The extract after being twice filtered in the ordinary way, was finally cleared by adding shredded filter paper. Sugar was then added to make up to about a 20 per cent. solution, which was then divided into three lots. One of these was heated to 80° C. for a few minutes in order to destroy the enzyme if any were present, and this served as a control. Chloroform was added to all three. The results were, stated as before, as follows:

	Sept. 26	27	30
No. 1 (control)..................	23.96	23.96	23.99
No. 2	23.96	23.86	23.62
No. 3	23.96	23.86	23.62

These last results are very consistent, and taken with those of the first experiment show clearly that an inverting enzyme is contained in the *Colletotrichum* mycelium, also that the failure of the

* Reading uncertain.

second experiment to give similar results was probably due to the use of alumina cream, which held the invertase.

In the first of the second series of experiments, the clear solution in which the fungus had grown was used to try to separate out the enzyme. Following the method of O'Sullivan and Tompson, as described by Reynolds Green, alcohol was added to the solution to a strength of 47 per cent. An appreciable white precipitate was thrown down, allowed to settle, and washed with 47 per cent. alcohol. It was thought that this precipitate must be the enzyme, as there was nothing in the original solution that would be thrown down by alcohol of this strength. The precipitate was, however, soluble only with some difficulty in water. The part which dissolved was added to two flasks of sugar solution, a third part of the same sugar solution being kept as a control. Chloroform was added to all these.

After three days there was no falling off in any of the polariscope readings, proving at all events that the chloroform was a sufficient preservative.

The next experiment was carried out in the same manner, except that the sugar solution had the mycelium growing in it for fourteen instead of seven days. Great care was exercised all through, not in any way to risk destroying the enzyme. The readings were kept up for four days, during which there was no inversion.

It seemed that the only possible explanation of the inaction, if there were any secretion of invertase, must be that the alcohol had destroyed its inverting power. Invertase is known to be an extremely delicate enzyme, easily injured by a number of chemicals, among them alcohol, but the strength used was supposed to have a minimal effect.

In the next test the solution filtered clear from the mycelium was used without any attempt at precipitation, though it was feared it might be too dilute a solution of the enzyme to give any definite results. About 300 c. c. were taken and sucrose added to make about a 20 per cent. solution. This was divided into three flasks, one of which was then heated to 80° C. for a few minutes, and served as a control. Chloroform was added as before. The results were as follows, the figures being grams per 100 c. c.

	Sept. 24	25	26	27
No. 1 (control)	19.98	19.93	19.93	19.92
No. 2	20.00	19.90	19.71	19.51
No. 3	20.00	19.90	19.71	19.53

The results are thus very consistent, and show a distinct inversion which must be due to invertase. The slight inversion in the first flask may be due to small traces of the invertase not being destroyed by the heating, or to a purely chemical inversion by the salts present.

It was then decided to test the matter further by keeping some of the inverting solutions at a temperature of 40° C. in an incubator. If the inversion were really due to invertase the rate should be considerably higher at the higher temperature. Five flasks were used for this test; No. 1 was the control, Nos. 2 and 3 were kept as before at room temperature, while Nos. 4 and 5 were kept at 40° C. The following results were obtained:

Dec.	2	3	4	5
No. 1 (control)	19.52	19.52	19.52	19.46
No. 2	19.52	19.07	18.87	18.65
No. 3	19.52	19.07	18.87	18.65
No. 4	19.52	18.57	18.00	17.37
No. 5	19.52	18.57	18.00	17.37

The results are seen to be even more consistent than was to be expected. In the incubated flasks two and one-half times the amount of sucrose was inverted as in those at 25° C. The experiment, with the last, proves beyond any reasonable doubt that invertase is not only contained in the mycelium of *Colletotrichum* but is actually secreted into the medium in which the fungus is growing.

Summing up the results of the inversion experiments, as a whole, the following statements can be made:

1. The main action of the fungus is the conversion of sucrose into invert sugar.

2. The invert sugar destroyed is very small in amount, and appears to be all levulose.

3. The inverting power of the fungus is due to the secretion of a definite enzyme, invertase, which can be proved to be contained in the mycelium, and also to be secreted into the media in which the fungus is growing.

4. *Colletotrichum* invertase appears to be more delicate than that obtained from yeast; so much so that its inverting power is destroyed by contact with 47 per cent. ethyl alcohol. The invertase is also carried down from its solutions by alumina cream, even when this latter is simply shaken up in the solution. A temperature of 80° C. is sufficient to destroy the invertase, even in presence of 20 per cent. sugar.

OTHER ENZYMES.

It is evident that *Colletotrichum* must be able to secrete some substance which will dissolve the cellulose cell-walls of the sugar-cane tissue, otherwise the fungus would not be able to pass from one cell to another in the way it has been proved to do.

One or two attempts were made to try if the secretion of a cellulose-dissolving enzyme could be detected in pure cultures, without much success. In one test, flask cultures of the fungus in water, containing besides nutrient salts and a trace of sugar, some cotton fibres, were started. The fungus grew very poorly, and was evidently unable to utilize the cellulose as a source of food. Microscopic examination of the fibres, however, did show a difference between some of those in the inoculated flasks and those in the control, where they had been kept for the same length of time in the same solution. The appearance of the two sets of fibres is shown in Fig. 14, those from the inoculated flask, on the right, have swollen up, straightened out, and show absolutely no structure, appearing like flat, colorless ribbons; the others show the normal structure and twisted course of the cotton fibre.

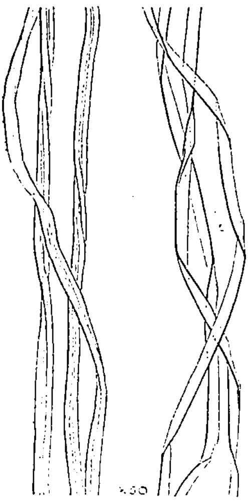

Fig. 14. Cotton fibres illustrating the apparent action of *Colletotrichum* on cellulose. The fibres at the right are typical of those that were left for some time in water in which the fungus was growing; the others are typical of the fibres in the control flask.

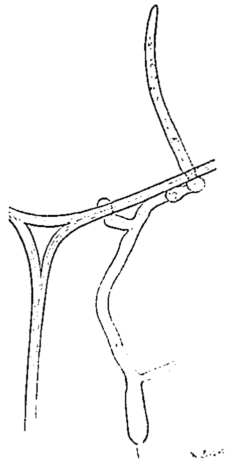

Fig. 15. Hypha of *Colletotrichum* from a hanging drop culture in water in which a section of elder pith was suspended. In a few cases as in that shown in the figures there appeared to be no doubt that the hyphae had bored their way through the walls of the empty pith cells.

The attempt was also made to grow the fungus in hanging-drop cultures with a thin section of elder pith. In most cases the hyphae seemed to avoid the cell walls of the pith, growing along them or passing above or below them in the drop. There were a few cases, however, where there seemed to be no doubt that hyphae had passed through the walls, constricting as they did so; one such case is shown in Fig. 15; here the most careful microscopic examination and focusing seemed to show that hypha and cell-wall were in one plane; many cases were seen in which I could not be quite certain of this.

It would seem, then, that the cellulose-dissolving powers of *Celletotrichum* are quite restricted, and are probably confined to the tips of actively growing hyphae. There certainly is no abundant secretion of a cytolytic enzyme.

TREATMENT.

Wakker and Went state that the treatment of Red Rot is very difficult. This is true in the sense that it is intended by these authors, namely, that the first step in the treatment of any disease is its recognition, and as already pointed out red rot is an extremely difficult disease to recognize in minor attacks. Once, however, the presence of a disease is recognized, and its nature identified, red rot is one of the diseases of the sugar-cane where treatment is most simple and likely to be most successful. The essential point on which treatment is based is the comparatively scanty production of spores by *Colletotrichum*.

Selection of Cuttings.

If the general recommendations, as to the selection of sound cuttings for planting, consistently recommended by this Division are thoroughly and steadily carried out, as they are on a number of plantations, there will be little danger of a general outbreak of red rot.

I have already pointed out that in epidemics of red rot the most common method of spreading the disease is by the planting of diseased cuttings. The outbreak described by Butler is a case in point. When this happens the eyes may not germinate at all, or they may produce young shoots which are soon followed up and killed by the fungus; again the fungus may never gain the upper hand entirely, but the canes produced will be stunted, and will have a low sucrose content. It will be seen that, unless care be taken in seed selection, the disease may easily be spread over a considerable area before it is known to be present.

Even when the disease has made considerable headway it is still possible to suppress it by throwing out everything but healthy cuttings. In this we rely upon the rarity of the spores and the dying out of any fungus in the soil. It is not suggested that the disease can be got rid of entirely by the first selection; there will be cases where the cut ends are free while the other internodes are diseased, and such cuttings will carry on the disease again. But after a few years if every cutting showing any discoloration, especially in the 'pith,' is thrown out, the disease should be reduced to those cases where infection has taken place from the outside.

For a more detailed account of the selection of cuttings Bulletin No. 1 of this Division should be consulted.

RESISTANT VARIETIES.

It may happen that certain varieties of cane may be so susceptible to red rot that the most careful selection of cuttings will fail to reduce the disease to within manageable limits. Fortunately, if such a state of affairs should exist we still have a line of treatment which is certain to be efficacious, that is, by replacing the affected variety by others which are more resistant to the disease.

In every recorded outbreak of red rot there has been one variety which has been severely attacked, while others growing under apparently the same conditions and under the same chance of infection have remained entirely or practically free. In these Islands, Yellow Caledonia has been proved to be resistant, and this variety would probably be the first one tried in the event of such an outbreak.

Which line of treatment should be adopted first, will depend upon the value of the variety attacked. If it should be a valuable variety, greatly superior to any that are known to be resistant, it would be better to attempt to eradicate the disease, by careful selection, and possibly importing clean seed from another locality. If the variety be not markedly superior, it might be advisable to replace it at once by another more resistant one.

BORER.

Red rot seems to be connected with the Hawaiian Cane-borer (*Sphenophorus obscurus*), just as in these Islands rind disease is connected with leaf-hopper. The parallel, however, is not an exact one. As I have pointed out in another bulletin,[25] the leaf-hopper not only affords entrance to the fungus into the tissues of the cane, but also by its repeated attacks reduces the resistance of the canes, which thus become liable to the disease. The case is different with the borer, whose tunnels merely provide points of entry for *Colletotrichum*, and whose attack does not appear to affect in any way the resistant capacity of the cane.

The borer wounds form practically the only points at which the cane can be infected from the outside. The only other wounds which would serve are the cracks which are sometimes found in cane, particularly in certain varieties. Control of the borer, thus,

[25] L. Lewton-Brain: 'Rind Disease of the Sugar-Cane.' *ibid.* p. 30.

would mean control of external attacks of red rot, just as seed selection will control the internal attacks.

Destruction of Diseased Material.

Probably the greater part of the material attacked by red rot in these Islands is now being destroyed unwittingly, the canes being crushed and the megass afterwards burnt. This is as severe a method of destruction as could be recommended, and should be continued, even though the sugar hardly be worth extraction. Only by some such thorough destruction of all 'borer' canes can the continuous risk of infection be avoided.

SUMMARY.

1. Red rot of the sugar-cane stem, caused by *Colletotrichum falcatum,* was originally described from Java; it has since been recorded from Madras and Bombay in India, from the West Indies, from Queensland, and it appears to be present in Mauritius.

2. There is no evidence that there has ever been a severe epidemic of the disease in Hawaii, but what evidence there is goes to show that occasional outbreaks are more frequent than is suspected, and that these are unnoticed or are referred to 'borer.'

3. The disease has no external symptoms by which it can be immediately recognized, and it is probable that the first indication of an outbreak of red rot will be a noticeable falling off in the sugar content of the cane. The internal lesions are described and illustrated, the most characteristic appearances are white spots surfounded by a well-defined red border; these, however, do not always occur. Always, it would appear, the disease is confined to the central sweeter tissues.

4. *Colletotrichum falcatum* appears to reproduce somewhat infrequently in nature. Basidia, bearing the one-celled colorless conidia, are formed on small stromata; sterile setae also arise from the stromata. In pure culture the stromata and conidia are produced abundantly. The color of the stroma varies from pale yellow or pink to black. The fungus grows well on a variety of media and apparently the same media that favor vegetative growth, favor the production of conidia, these are, principally, media rich in sugar. Chlamydospores are found in nature, and at all stages of growth in cultures; their production is more abundant on unfavorable media.

5. The fungus is a wound parasite, and in these Islands enters cane usually through the wounds made by borer (*Sphenophorus obscurus*). It may also be perpetuated by the planting of diseased cuttings. The damage done will vary with the variety

attacked; it may result in the death of the canes, but in most cases will not affect the general nutrition of the canes, and the damage done is confined to the destruction of the sucrose. This loss may be very considerable as the analyses of diseased canes show.

6. An extensive series of experiments has been carried out, bearing on the power of the fungus to invert sucrose, the experiments are fully described and a number of analyses given. The fungus will invert nearly the whole of the sucrose in a solution, converting it into dextrose and levulose, while very little sugar is actually destroyed. The loss seems to fall entirely upon the levulose. It was shown that an inverting enzyme is present in the mycelium, which can be extracted by grinding up the mycelium with quartz sand or glass wool. This enzyme was also proved to be secreted into the culture fluid. The invertase is carried down from solutions by alumina cream, and appears to be extremely sensitive to the action of alcohol, the percentage required to precipitate it being sufficient to destroy its inverting powers.

7. The careful selection of cuttings promises to be a successful treatment for red rot, provided the comparatively scanty production of spores is maintained. If this measure fails, it is certain that the disease can be dealt with by the introduction of resistant varieties; among Hawaiian varieties, Yellow Caledonia (White Tanna) has been proved by the inoculation experiments to be quite resistant to the disease. The destruction of diseased material, preferably by passing the cane through the mill and then burning the megass should not be neglected.

The figures are all drawn by Mr. W. E. Chambers from the author's preparations. Figures 3, 4, 7, 8, 9 and 11 have been previously used in Bulletin No. 7, of this Division.

The author's thanks are also due to Mr. J. C. de Jager for a translation of Wakker & Went's article on Red Rot which is referred to in the text.

SUGAR INDUSTRY IN ANTIGUA.

Sugar has always been, and there appears very likelihood of it continuing to be, the staple product of the island.

When the Imperial Department of Agriculture was inaugurated in 1899, the industry was suffering under a wave of great depression. It had barely emerged from a fierce struggle with the ravages of rind fungus, a struggle in which it is more than likely it could not have survived had it not been for the existence of the Government sugar experiment station which supplied the

White Transparent cane to replace the too easily attacked Bourbon. Further, the existing machinery for the manufacture of sugar on estates was of such antiquated and inefficient description that heavy losses in manufacture were the order of the day. In addition, the market price of sugar, under the influence of continental bounties and cartels, had sunk to such a low ebb that it was actually below the cost of production on the most economical lines.

Under these conditions, the industry was confronted with the prospect of immediate extinction. The cry for improved methods of manufacture was vainly raised. It was impossible to attract sufficient capital to allow of the introduction of the central factory system, with the instability of prices incident on the bounty system.

The donation of a free grant to the industry by the Imperial Government sufficed to bolster it up for a period, but there was no prospect of such a dole having any permanent effect.

With the prospect of the abolition of bounties, however, the industry took to itself a new lease of life, consequent on the stability likely to be imparted to it thereby.

With this material improvement in prospects, strong efforts were once again made to introduce the central factory process of manufacture in place of the existing muscovado method, and these labors were eventually crowned with success.

The year 1903 saw the first introduction of central sugar factories into Antigua, under the governorship of Sir G. Strickland.

To assist in their erection, two grants were made by the Imperial Government, one of £15,000 to the Antigua Sugar Factory Company, Ltd., which has since erected the central factory at Gunthorpe's, and one of £3,000 for the reconstruction on modern lines, of the plant at Bendal's, on the group of estates known as Belvidere.

Both these enterprises are now working, and the island at the present time possesses two up-to-date factories capable of turning out a combined output of some 6,000-7,000 tons of grey crystal sugar, of which Gunthorpe's is responsible for 4,000-5,000 tons, and Bendal's for 2,000 tons.

Both factories are bound by the terms of the contract under which they received their respective grants from the imperial Government, to purchase annually, if tendered, canes grown by peasants to the amount of 4,500 tons in the case of Gunthorpe's, and in the case of Bendal's 1,500 tons. The price to be paid for such canes is fixed fortnightly according to the state of the market, by a board appointed for the purpose by the Government, of which the Superintendent of Agricultutre is the Chairman. Under the contract, this price must never be less than *7s. 6d.* per ton.

These factories have now been in operation for three years in the case of Gunthorpe's, and four in the case of Bendal's, and during that time their usefulness has been amply demonstrated.

Additional estates have come into the scheme under which the Gunthorpe's factory is constituted, and on all sides planters are coming to a full sense of appreciation of the factory system.

The scheme for the purchase of peasants' canes has resulted in material benefit to the laboring classes, and although, during the earliest stages of the existence of the factories, peasants were somewhat slow to take advantage of the opportunities offered, they have now been fully realized, and both factories annually purchase at the present time more than their contract amount of such canes.

By the establishment of central sugar factories in Antigua, a degree of stability has been imparted to the sugar industry which it formerly lacked, and there can be little doubt but that, if a continuation of the conditions inaugurated by the Brussels Convention were ensured, other similar factories would speedily follow.

The progressive policy inaugurated in this way has been followed by similar advances on estates themselves.

Two complete sets of steam-ploughing machinery have recently been introduced into the island, which by reason of the deeper and more thorough cultivation attending their use, should greatly improve soil conditions and yields on the estates concerned.

In addition, an important and extensive series of cultural experiments has recently been started on one estate, designed to test the relative value of the local methods of cane cultivation as compared with that of the agricultural practice of other cane-producing countries.

Furthermore, the extensive series of cane experiments controlled by the Department of Agriculture has been the means of providing estate managers and owners with the possibility of readily introducing improved varieties of cane for trial on estates, an opportunity which is largely taken advantage of. The system under which these experiments are carried on gives the manager a chance of judging for himself how far the different varieties grown are suitable to the conditions obtaining in the locality in which his own estate is situated. A similar remark applies to the manurial experiments.

The foregoing brief review will enable it to be readily seen to what a large extent the prospects of the sugar industry have been improved. It may be safely said that at no time during the last twenty years have the conditions of the industry been more favorable.

SUGAR CANE EXPERIMENTS.

An account of agricultural efforts in Antigua during the existence of the Department of Agriculture would be incomplete without some mention being made of this branch of the work which has for years constituted one of the most important features of departmental activity.

It is true that the supervision and control of sugar cane experiments does not at present constitute an integral part of the duties of the Curator, but under the system now in vogue, whereby the Superintendent of Agriculture has control of all departmental work, it follows that no one branch of it can be said to be completely dissevered from any other. Further, it is contemplated in the future to bring the supervision of these efforts more directly under the control of the station.

As has been stated in an earlier portion of this report, experiments with sugar cane were inaugurated at the time of the institution of the Agricutural Department in 1889, by the local Government (see p. 1). These experiments were carried out on the Government experimental fields at Skerrett's under the supervision of the Government Chemist and the Superintendent of the Boys' Reformatory continuously until 1899, when the Imperial Department of Agriculture was instituted. During the time of their existence, they served a useful purpose, and the results obtained were largely instrumental in tiding the sugar industry over the great wave of depression incident on the rind fungus epidemic of 1895 to 1898.

Upon the inception of the Imperial Department of Agriculture, sugar cane experiments on a much more extensive scale were instituted. The plan adopted was to establish these experiments on various estates throughout the island in coöperation with the management, and they have been carried out during the last ten years with conspicuous success. It is an essential feature of these experiments that the canes shall be cultivated on precisely the same lines as prevail in the ordinary cultural operations of the estate.

At the present time, there are eight experiment stations in the island where experiments with cane varieties are carried on, and at all these stations they are conducted both with plant canes and first year ratoon canes.

The various experiment stations represent the extreme range of climate and soil prevailing on the cane lands throughout the island. At each station, twenty cane varieties are planted in experiment plots. Each station has a series of twenty plots, in duplicate.

It will be seen that under these conditions the cane planter is placed in the most favorable position for observing the growth of the different varieties experimented with, and for forming his own conclusions therefrom.

The canes from these experiment plots are crushed in the experimental mill belonging to the Department, and the juice from each plot is analyzed at the Government laboratory. Each year a report is published dealing with the results obtained in this direction during the past twelve months. These experiments receive a large amount of attention and appreciation, and each year the interest taken in them has increased.

In addition to experiments with varieties of cane, manurial experiments are carried out on similar lines to the variety experiments. There are at present five experiment stations on estates in Antigua devoted to the investigation of the manurial experiments of the sugar cane. At present, these experiments are only carried out on ratoon canes. Until recently, experiments were performed both on plant and ratoon canes, but it has been demonstrated so clearly by them that, under the cultural conditions prevailing locally, a good dressing of pen manure is all-sufficient for the needs of *plant* cane on moderately well cultivated land, that it has been taken as proved that the manurial requirements of *plant* cane, under the conditions prevailing in Antigua, require no further investigation.

With regard to ratoon canes, it has been the practice in the past to investigate their manurial requirements on plots which had borne similar experiments when cultivated under plant cane, and under these conditions it has been found that a moderate dressing of nitrogenous artificial manure is beneficial and remunerative. Since, however, it has been shown that plant canes do not require artificial manure, it is obviously necessary to ascertain the effect of artificial manures on ratoon canes that have not received similar applications as plants.

Accordingly, experiments designed to investigate this point have been recently inaugurated. It is as yet too soon to be able to draw any definite conclusions from them, but it is anticipated that the manurial experiments to be carried out in the next few years should largely tend towards the investigation of this point, and it is hoped that they will eventually yield reliable information.

SEEDLING CANES.

Attempts have frequently been made to raise seedling canes from seed in Antigua, but, in the great majority of cases, they have failed. It is believed that in Antigua conditions are usually such that cane seed is commonly infertile, owing to the exceeding dryness of the climate.

Only on two occasions have cane seedlings been successfully raised in Antigua. In 1901-2, three seedlings were raised, and in 1902-3, some 300 were raised—on both occasions under the hands of Mr. W. N. Sands, then Curator of the Botanic Station. These seedlings are still under experimental cultivation at the present time, with a view to ascertaining whether any of them are worthy of continued propagation.—Report of Department of Agriculture, West Indies.

SOME LATE THEORIES ON THE PROCESS OF FERTILIZATION.

The making of experiments in agricultural lines would seem at first thought to be comparatively easy of realization. But this is not the experience of the farmer, who must acquire, in a small way, year by year, the knowledge that eventually evolves the skillful practitioner. Experiments in agriculture involve so many unknown and undeterminable factors in their results that they almost invariably lose the character of exactness and accuracy. For example, for many years a method had been sought which would induce a larger yield of sugar in sugar beets; but it was not until hundreds of systematic, methodical experiments had been made, covering the whole of France, that a means was discovered to increase the saccharine richness of these vegetables.

We do not know the exact conditions upon which the outcome of our attempts depend; they are numerous and complex, and it is for this reason that often in agricultural experiments it is impossible to obtain the precise results twice in succession. The highest successes in agricultural experimentation have usually been made by those who have had recourse to the chemical laboratory. The role played by fertilizers, for example, has never been so clearly demonstrated as by the work of M. G. Ville, in his vessels filled with calcined sand steeped in various saline solutions.

The ideas of Liebig and of Dumas upon fertilization have been universally admitted for a half century, until during the past few years, through much labor of a very interesting character, many of our beliefs have gone through something of the nature of a revolution. American agricultural experimenters have worked out many new theories recently, based upon a vast number of proved field and laboratory tests.

The investigations of the Frenchman, G. Bertrand, upon the role played by manganese salts in diastase reactions have inspired a long series of cultural trials, the results of which have been interesting and significant. That these attempts have not shown perfect coördination as yet, is to be expected, because of their extreme novelty and the incompleteness of the experiments. Yet, as far as they have been carried out, they have served to make us better acquainted with many puzzling problems and furnished us with better explanations of known facts than we had possessed before.

"All the rocks which enter into the substance of the soil are susceptible to alteration, and their alteration is due to two phenomena, disintegration and decomposition." (*Cayeaux, Revue de viticulture*, 1905.) This is the generally accepted belief, and a natural one gained from ordinary methods of observing the composition of soils. But Delage and Lagatu (*Delage et Lagatu, Constitution de la terre arable*) employed in their analysis a novel process. Fine earth, after drying and sifting, was agglomerated with water and a species of glue and then dried. The mass then attained the consistency of rock and it was possible to effect an analysis by ordinary mineralogical methods. From the mass was cut extremely thin sections (one-hundredth millimeter) which were placed under polarized light on the stage of a microscope. The polarizer revealed a state exactly identical with that of the primitive rock from which the soil was formed. The mineral species were observed in a state of perfect purity, that is to say, in the state in which they were found in the original rock. The conclusion seemed to be that in the formation of soils there is no decomposition of the rock, but disintegration solely. This fact has been corroborated by the results of a number of analyses made in the United States by the Bureau of Soils, Department of Agriculture, and Milton Whitney, of the Department, thus sums up the matter: "Soils are simply non-agglutinated rock;" and further on he says: "Soils are no more than powdered rock." (*In a conference with Maryland agriculturists.*)

Plants, thanks to the acid secretions of their radicals are able to absorb directly the insoluble mineral matter. It is an observed fact that cultures placed in a vessel with interior walls of polished marble has engraved upon them the intaglio image of the rootlets of the plant. However, in practice, the soluble phosphoric acid of the super phosphates, for example, gives results incomparably superior to those produced by the natural insoluble phosphates.

American chemists of the Bureau of Soils have tested a great number of soils, not only in the ordinary manner with hot hydrochloric acid, but by centrifuging finely ground soil in water. They recognized that the water thus obtained, whatever the composition or constitution of the soil always contained minute quantities of potash and phosphorous—very little, yet sensibly present, and more than sufficient for the nutrition of plants. According to the experiments of Schloesing, this quantity was sometimes found to be equal to no more than one-millionth of the total mass. How then, explain the role of fertilizers, if, by their faculty of assimilating directly from the rock elements, plants have always at their disposition a sufficient quantity of mineral nutriment?

The soil, in addition to the rock powder and the liquids which percolate through it, contains organic debris, and an atmosphere different from the ordinary air, being much richer in carbonic anhydride and vapor of water.

It conceals a bacterial flora very rich, finding in the composition of the atmosphere and the liquids of the soil a remarkably suitable medium for the production of diataste. Taking into consideration the complexity of the composition of the soil it was quite justly said by Berthelot that "the soil is a living organism." The work performed by these living atoms is not one of the least of the phenomena of cultivation and of growing vegetation.

Wheat, after being allowed to grow in a pot for six weeks, is removed from the earth. If a second sowing is made in the same soil, with seed of the same species, the development of the wheat is inferior by half. Another trial is made after having added to the pot the ashes of the first crop. The new crop results in no improvement. And meanwhile the soil has not been exhausted of the elements called "fertilizers." On the contrary, by the addition of the entire first crop, after calcination, the soil in the pot conserves its primitive fertility. It is known from other researches, that the addition, even of considerable quantities of fertilizer, does not alter more than to a comparatively limited extent the contents of the soil in fertilizing material.

A great deal of our cultivated land includes as much as 4,000 kilos of phosphoric acid to the hectare, says Deherain. Berthelot and Andre have found more than 35,000 kilos of potassa per hectare in the utilizable part of a field. (*Annales de Chimie et de Physique; serie 6, t, XV.*) And we have seen that these principles are soluble and assimilable.

How is it then that the application of a few hundred kilos sensibly increases the crop. Taking up again the old theory of Candolle, the American school advances the idea that the soil is polluted by the excrements of the plants.

Jansen was unable, notwithstanding the employment of fertilizers, to make herbs grow in a soil on which certain trees had been grown. Seeking for an explanation of this fact, by experiments in the laboratory, he found that in an artificial medium, where he had produced a crop of wheat, the soil became toxic for wheat, but not for other plants. Thus fertilizers, as well as other various agents of fertilization, plowing, harrowing and aeration of the soil, act by destroying the poisons or toxins lying in the ground left by the preceding crop. The hypothesis appears to be quite plausible. "We have not been able yet to isolate these toxins," says Milton Whitney, "but we have identified a few."

The few that we know reveal many common characteristics, and toward all of them the diastases appear to act as an anti-toxin. Is it not possible that all fertilization, natural or artificial, exerts its beneficial action by a diastastic action which results in the destruction of the vegetable toxins by the anti-toxins of the bacteria of the soil or applied under the form of fertilizer.

After the work of G. Bertrand in the matter, we know that manganese performs some part in the formation of diastase. We call to mind the fact that this savant obtained varieties of diastase synthetically by the combination of manganese with organic acids, and that the product was much more active than the acid radical of the combination, and of a higher molecular weight. Now from this series of experiments it appears that a fertilizer with a manganese base should aid in the formation of anti-toxins by the manufacture of diastase in the soil. Trials have been made in Germany and France, to determine this question, and Voelker found that sulphate of manganese would increase the weight of a given crop, but only when applied in small quantities, about 25 kilos to the hectare. In larger applications the manganese was injurious. Leow and Sawa, (*Revue genérale de Chimie,* 1904, p. 385), in Japan, also found that manganese salts, in light dosage, proved a stimulant of an energetic character. The plants obtained from their cultures were extraordinarily rich in oxydases, which seemed to prove the hypothesis of the investigators to be well founded. Gregory (*Revue Scientifique,* 1907) employed manganese in the culture of sugar beets and potatoes; while the weight of the latter was augmented, the weight of the beets was diminished, but the sugar content was increased.

From all the foregoing it will be realized that the whole problem of soil action, of toxin and anti-toxin, and the role of manures and fertilizers is not yet fully settled; that there still remain many problems to be investigated. In agriculture, as in other branches, we have not yet reduced our evidence to an exact science, and there are yet many facts in physical and chemical science which must be taken up by investigators in logical order. But while we do not know exactly the factors which influence crops nor the mechanism which controls their action we have made great progress in agricultural science, and the future holds excellent promise for the days that are to come.—Translated from "*L'Engrais*" for The American Fertilizer.

Sugar Plantations, Cane Growers and Sugar Mills.

ISLAND AND NAME.		MANAGER.	POSTOFFICE.
OAHU.			
Apokaa Sugar Co	*	G. F. Renton	Ewa
Ewa Plantation Co	*	G. F. Renton	Ewa
Waianae Co	***	Fred Meyer	Waianae
Waialua Agricultural Co	*	W. W. Goodale	Waialua
Kahuku Plantation Co	x*	Andrew Adams	Kahuku
Waimanalo Sugar Co	**	G. Chalmers	Waimanalo
Oahu Sugar Co	x	E. K. Bull	Waipahu
Honolulu Plantation Co	**	Geo. Ross	Aiea
Laie Plantation	x*	S. E. Wooley	Laie
MAUI.			
Olowalu Co	**	Geo. Gibb	Lahaina
Pioneer Mill Co	x	L. Barkhausen	Lahaina
Wailuku Sugar Co	**x	C. B. Wells	Wailuku
Hawaiian Commercial & Sugar Co	x*	F. F. Baldwin	Puunene
Maui Agricultural Co	...	H. A. Baldwin	Paia
Kipahulu Sugar Co	x	A. Gross	Kipahulu
Kihei Plantation Co	x*	A. J. McLeod	Kihei
Kaeleku Plantation Co	...	John Chalmers	Kaeleku
HAWAII.			
Paauhau Sugar Plantation Co	**	James Gibb	Hamakua
Hamakua Mill Co	*x	A. Lidgate	Paauilo
Kukaiau Plantation	x	A. Horner	Kukaiau
Kukaiau Mill Co	*x	E. Madden	Paauilo
Ookala Sugar Co	**x	W. G. Walker	Ookala
Laupahoehoe Sugar Co	*x	C. McLennan	Papaaloa
Hakalau Plantation	**	J. M. Ross	Hakalau
Honomu Sugar Co	**x	Wm. Pullar	Honomu
Pepeekeo Sugar Co	**x	Jas. Webster	Pepeekeo
Onomea Sugar Co	**x	J. T. Moir	Hilo
Hilo Sugar Co	**	J. A. Scott	Hilo
Hawaii Mill Co	x	W. H. Campbell	Hilo
Waiakea Mill Co	*x	C. C. Kennedy	Hilo
Hawaiian Agricultural Co	**x	Wm. G. Ogg	Pahala
Hutchinson Sugar Plantation Co	**	Carl Wolters	Naalehu
Union Mill Co	*x	H. H. Renton	Kohala
Kohala Sugar Co	*	Geo. C. Watt	Kohala
Pacific Sugar Mill	x**	A. Ahrens	Kukuihaele
Honokaa Sugar Co	x**	K. S. Gjerdrum	Honokaa
Olaa Sugar Co	xx	J. Watt	Olaa
Puna Sugar Co	xx		Kapoho
Halawa Plantation	x*x	J. Atkins Wight	Kohala
Hawi Mill & Plantation	††	John Hind	Kohala
Puako Plantation	††	Jno. C. Searle	S. Kohala
Niulii Sugar Mill and Plantation	*x	Robt. Hall	Kohala
Puakea Plantation	...	H. R. Bryant	Kohala
Kona Sugar Co	...	....	Kona
KAUAI.			
Kilauea Sugar Plantation Co	**	F. Scott	Kilauea
Gay & Robinson	x*x	Gay & Robinson	Makaweli
Makee Sugar Co	...	G. H. Fairchild	Kealia
Grove Farm Plantation	x	Ed. Broadbent	Lihue
Lihue Plantation Co	x	F. Weber	Lihue
Koloa Sugar Co	x	L. Weinzheimer	Koloa
McBryde Sugar Co	*x	W. Stodart	Eleele
Hawaiian Sugar Co	x*	B. D. Baldwin	Makaweli
Waimea Sugar Mill Co	*	J. Fassoth	Waimea
Kekaha Sugar Co	x	H. P. Faye	Kekaha

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***	J. M. Dowsett	(1)
x	H. Hackfeld & Co	(9)
*x	T. H. Davies & Co	(8)
**x	C. Brewer & Co	(6)
x*	Alexander & Baldwin	(6)
x**	F. A. Schaefer & Co	(2)
x*x	H. Waterhouse Trust Co	(2)
††	Hind, Rolph & Co	(2)
xx	Bishop & Co	(1)